APPENDIX C: ANALYSES WITH NO UPLIFT

1. Introduction

In an effort to simplify the comparison between the traditional method of analysis and the finite element/fracture mechanics based analysis, a series of analyses was performed for monolith 7E in which the uplift pressure at the base of the monolith was not considered (the culvert was considered in this case). Neglecting the uplift pressure greatly simplifies both the modeling of the structure and the computation of the stress intensity factors. The master and slave nodes required to model that portion where the uplift pressure was applied as pore pressures (initial stresses) were not present in the mesh used for these analyses. Otherwise the mesh was identical to the one shown in Figure A-4 of Appendix A. The material properties and the remaining applied loads for this investigation were not changed from those used for the analyses described in Appendix A in which uplift was considered.

2. Analysis and Results

a. Estimation of crack length.

(1) A series of three analyses, each with a different specified crack length, was performed to compute an initial estimate of the final crack length. The prescribed crack lengths for these analyses ranged from 6.0 ft to 9.0 ft in 1.5-ft increments. No analyses were performed for crack lengths greater than 9.0 ft because the value of K_I was negative for a crack length of 9.0 ft and K_I was positive for all prior analyses. The final crack length of 8.58 ft was found by re-meshing and comparing K_I to K_{Ic} as described in paragraph 3*d*(1) of Appendix A. However, since initial stresses were not prescribed for elements adjacent to the interface between the monolith and the foundation, it was required only to reposition the pair of nodes on the monolith/foundation interface. The results of these analyses are summarized in Table C-1. The variations of K_I and K_{II} over the range of crack lengths are shown in Figure C-1.

(2) The final crack length computed using the traditional method of analysis was 9.55 ft. The value of 8.58 ft computed using finite element analysis and fracture mechanics is only 10.2% less than 9.55 ft. When uplift was considered, the discrepancy between the final crack lengths was 43.7% (see Appendix A), which is over four times the 10.2% predicted for this case. The improved agreement in the predicted final crack lengths may be an indication that the crack length of 8.58 ft is not long enough to be strongly influenced by the culvert. Even though the culvert is relatively large in relation to the monolith, the influence that it would have on the stresses and displacements at the base of the monolith is greatest near the culvert and decreases as the distance from the culvert increases. Based on the observed results, the discrepancy between the two methods of analysis would be even less if both the culvert and the uplift were not considered.

b. Normal stress profiles.

(1) The normal stress profile along the base of the monolith with a crack length of 8.58 ft and no uplift is shown in Figure C-2. In order to contrast the difference between the traditional and proposed methods of analysis, the normal stress profile from the traditional method of analysis is also included in Figure C-2. In comparing Figure C-2 (no uplift case) with Figure A-11 of Appendix A (full uplift case) the effect of the uplift on the normal stress profile is minor considering the overall shape of the

Table C-1
Summary of Finite Element Analyses With No Uplift

a ft	K_I ksi$\sqrt{\text{in.}}$	K_{II} ksi$\sqrt{\text{in.}}$	CMOD in.	ΔH_{crest} in.
6.00	0.411	0.536	0.00800	-0.0762
7.50	0.188	0.536	0.00843	-0.0777
8.58	0.000	0.547	0.00842	-0.0781
9.00	-0.132	0.578	0.00835	-0.0781

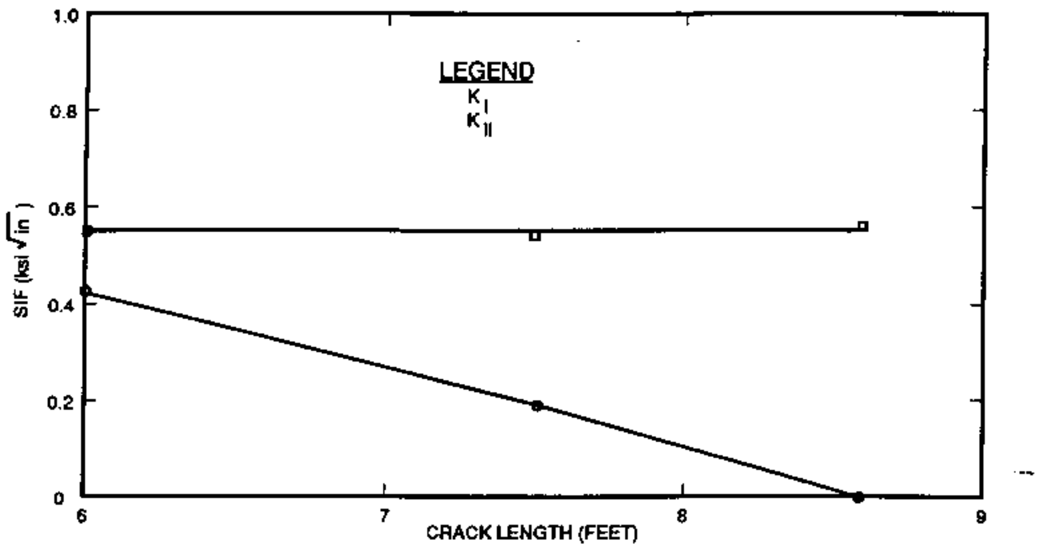

Figure C-1. K_I and K_{II} versus crack length for monolith: no uplift

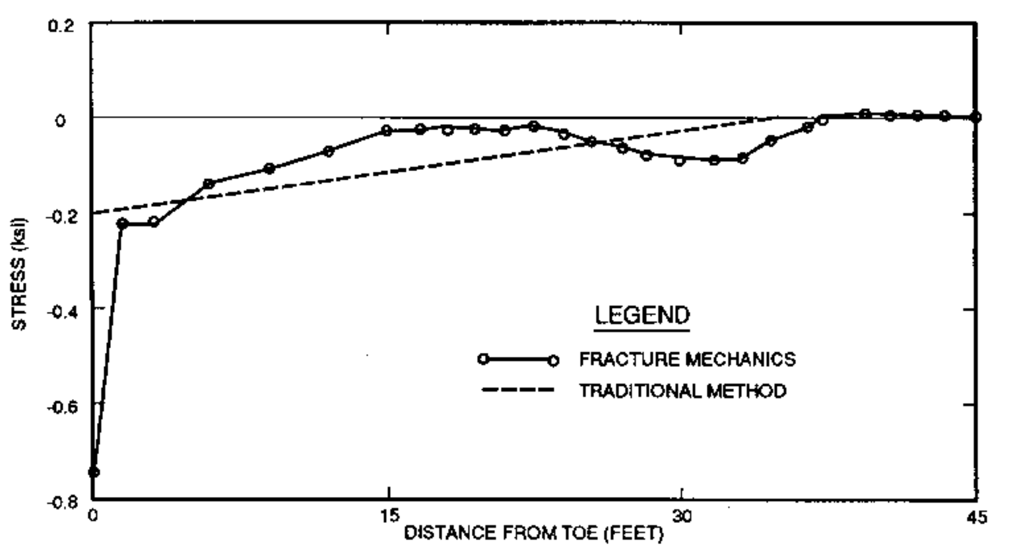

Figure C-2. Normal stress profile at the base of monolith for a *a* = 8.58 ft: no uplift.

curves. In all plots showing normal stress profiles (Figures A-11 of Appendix A, B-2 of Appendix B, and C-2), the normal stress near the crack tip is a relatively small negative value instead of zero. These errors in the normal stress are a consequence of the nodal strain projection technique, which is very sensitive to the level of mesh refinement around sharp corners and notches. However, the normal stresses on the crack surface at a short distance away from the crack tip are zero in all cases. This demonstrates that the effect of the crack tip on the nodal stresses is indeed local and that the small error in the normal stress at the crack tip should not be a cause for concern.

(2) The resultant force in the vertical direction and the line of action for the resultant force were computed for the finite element solution and the traditional analysis technique. Since uplift was not considered, the actual estimated final crack lengths for the two methods of analysis were used in these computations (with no uplift, the two systems are equivalent force systems regardless of crack length). The calculated resultant force from the finite element analysis was 519.41 kips as opposed to 515.90 kips from the traditional analysis technique. The line of action for the resultant force from the finite element analysis was 11.79 ft to the right of the toe as opposed to 11.82 ft from the traditional analysis technique.

c. Shear stress profiles. The shear stress profile along the base of the monolith for a crack length of 8.58 ft is shown in Figure C-3. In comparing Figure C-3 with Figure A-12 of Appendix A the effect of the uplift on the shear stress profile is minor in terms of the overall shape of the curves, as was the case with the normal stresses. However, the shear stress profile in Figure C-3 does show a slight increase between the right side of the culvert and the crack tip before going to zero on the crack surface. It could be argued that this demonstrates that the effect of the culvert on stresses (and displacements) at the base of the monolith may be limited to certain cases. The resultant force in the horizontal direction was computed for the finite element solution and the traditional analysis technique. The resultant force from the finite element analysis was 250.62 kips as opposed to 249.78 kips from the traditional analysis technique.

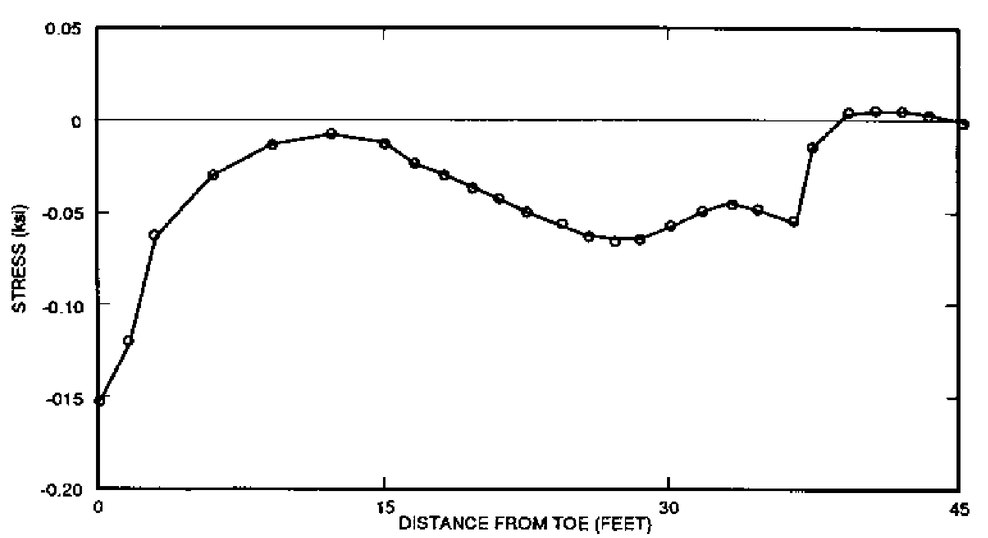

Figure C-3. Shear stress profile at the base of monolith for *a* = 8.58 ft: no uplift